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1995-96 School Year

Physics 30 Information Bulletin

Diploma Examinations Program

**Students
First!**
Student Evaluation

Alberta
EDUCATION

This document was written primarily for:

Students	✓
Teachers	✓ Physics 30 teachers
Administrators	✓
Parents	
General Audience	
Others	

Distribution: Superintendents of Schools • School Principals and Teachers • The Alberta Teachers' Association • Alberta Education • General Public upon Request

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Purpose of the Bulletin

The purpose of this bulletin is to provide students and teachers of Physics 30 with information about the diploma examinations scheduled for 1996.

We encourage teachers to share the contents of this bulletin with students and to review the scoring criteria with them.

If you have requests, questions, or comments about the contents of this bulletin, please contact:

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Important Dates in 1996

Administration of the Physics 30 Diploma Examination

<i>1996 Administrations</i>	<i>Time*</i>
Friday, January 26	1:00–3:30 P.M.
Tuesday, June 25	1:00–3:30 P.M.
Thursday, August 15	1:00–3:30 P.M.

* The diploma examination is designed for a writing time of 2.5 h.
Students may have an additional 0.5 h to complete the examination.

Scoring of the Examination

<i>1996 Administrations</i>	<i>Scoring Dates**</i>
January	February 6, 7 (Head Markers) February 8 to 10
June	July 7, 8 (Head Markers) July 9 to 12
August	August 17

** Dates are tentative and will be confirmed by telephone with markers.

Notes of Interest

Information About Markers

The written-response questions of the Physics 30 Diploma Examinations are marked by Physics 30 teachers selected from those who have been recommended as markers to the Student Evaluation Branch by their superintendents. To qualify for recommendation, a teacher must have taught the complete Physics 30 course twice, be teaching the course in the current school year, and have an Alberta or Northwest Territories Permanent Professional Teaching Certificate.

Often, more teachers are recommended as markers by superintendents than are required by the Student Evaluation Branch for any one marking session. The following criteria are considered when markers are selected for a particular marking session:

- experience as a marker (experienced markers and first-time markers are included)
- regional representation (by zone, jurisdiction, and school)
- student population (proportional representation)

We particularly need teachers who can mark examinations written in French.

Teachers who wish to be recommended as markers for the January 1996 examination should contact their superintendents by September 22, 1995. Teachers who wish to be recommended as markers for the June and August 1996 examinations should contact their superintendents by **February 23, 1996.**

Item Writing and Field Testing

As the need arises for teachers to participate in field testing and item writing, letters are sent to superintendents requesting their nominations. **Teachers who are interested in these activities should let their superintendents know by September 22, 1995.**

Reports

After each January and June administration of the Physics 30 diploma examination, copies of the *Examiners' Report* for that particular administration are sent to teachers in all senior high schools in Alberta. The report contains provincial results along with comments about student performance on the examination.

Examiners' reports are designed for teacher use. If we can make these reports more useful to you, please let us know.

School and Jurisdiction Statistical Reports are sent to each superintendent and senior high school principal after each January and June administration of the Physics 30 diploma examination. These reports provide detailed information on how well the students in their school district and school, respectively, did on the Physics 30 diploma examination. Teachers may use these data to reflect on the areas of the program where their students did well and those areas where student performance was poor.

Each year, copies of a document entitled *Annual Report, Diploma Examination Program* are sent to each superintendent and senior high school principal in Alberta. The report contains information about the results achieved by students who wrote diploma examinations in the school year. It also contains special studies on topics of interest. The first annual report (1989–90 school year) contains a study comparing achievement in various diploma courses. The second report (1990–91 school year) contains a study comparing the achievement of students who repeat diploma examination courses and rewrite diploma examinations with their achievement the first time and with the achievement of students who write only once. The third report (1991–92 school year) contains a study of participation rates in diploma examination courses. The fourth report (1992–93 school year) contains a study of English 30 students' application of conventions of language. The fifth report (1993–94 school year) presents a comparison of provincial participation rates in diploma examination subjects for the school years 1991–92, 1992–93, and 1993–94. Each of these special studies will be of interest to teachers who are involved in interpreting diploma examinations results of their students.

Inservices and Presentations

On a limited basis and subject to budget constraints, Student Evaluation Branch staff is available to provide inservices or presentations related to diploma examinations or the interpretation of diploma examination results.

Student Use of Scientific Calculators

Examinations are constructed to ensure that the use of particular scientific calculators neither advantages nor disadvantages individual students. Students are expected to provide their own scientific calculators.

Refer to Appendix A for the policy statement on the use of scientific calculators on diploma examinations. Students should be made aware of this policy as early as possible in the school term to ensure they are able to use the scientific calculator of their choice when writing examinations.

Students should also be made aware of the Examination Rules, Grade 12 Diploma Examinations (see Appendix B). Students should know that notes stored in electronic devices may not be brought into the examination room.

Data Resources for Students

The Physics 30 diploma examinations contain tear-out data pages. Students should remove the tear-out data pages from the exams at the beginning of the writing session. These pages do not have to be returned with the exam booklets and answer sheets. The data presented are generic for all of the Physics 30 diploma exams provided during a school year; therefore, only some of the data are useful for any particular exam.

Student Requests for Rescores

Students may request a rescoring of their diploma examinations. Before applying for a rescoring, students should check their Diploma Examination Results Statement to find out the distribution of marks. The mark on the machine-scored questions is not likely to change as a result of a rescore, but the written-response mark could change slightly. Students should remember that the rescored mark will be the final mark whether it *increases* or *decreases*.

Students who decide to have an examination rescored must ensure that their application is received before the deadline specified on the results statement. The fee for rescoring each examination is \$26.75, which includes GST. If a diploma examination mark is increased by 5% or more as a result of rescoring, the fee is refunded.

Student Requests for Rewriting

Students may rewrite a diploma examination in any regularly scheduled administration. Students must apply to the Student Evaluation Branch by November 15, 1995, and April 15, 1996, to be eligible to write the January and June diploma examinations. The tentative fee for rewriting each examination is \$26.75, which includes GST. (For more details, see the *General Information Bulletin*.)

Physics 30 Information

Objectives of the Course

Physics 30 is an academic course intended to further students' understanding and application of fundamental concepts and skills. The focus is on understanding the physics principles behind the natural events they experience and the technology they use in their daily lives. The course encourages enthusiasm for the scientific enterprise and develops positive attitudes about physics as an interesting human activity with personal meaning. It develops the knowledge, skills, and attitudes to help students become capable of, and committed to, setting goals, making informed choices, and acting in ways that will improve their own lives and life in their communities.

To develop the required knowledge, skills, and attitudes in Physics 30, it is necessary that students successfully complete Science 10 and Physics 20.

Standards

Student who attain an *acceptable* standard in Physics 30 received a final mark of 50% or higher. They have gained new skills and knowledge in physics but may encounter difficulties if they choose to enroll in post-secondary physics courses. These students can state and solve problems that can be related quickly to an equation on the data sheets. Their laboratory skills are limited to following explicit directions and to using laboratory data to verify known physics information. These students are capable of defining and calculating quantities such as one dimensional momentum; kinetic and potential energies; electric force and the force due to gravity; current, potential difference, and resistance in simple series and parallel circuits; variables in the relationship between the primary and secondary coils of a transformer; speed, wavelength, and frequency of electromagnetic waves; charge-to-mass ratios; and the photoelectric work function. They tend to use item-specific methods in their problem solving and rarely apply the major generalizations of physics such as conservation laws of charge, momentum, and energy. When explaining the connections between science, technology, and society, these students tend to use examples provided from textbooks and have difficulty connecting physics to real-life scenarios beyond the classroom.

Students who attain a standard of *excellence* in Physics 30 receive a final mark of 80% or higher. They have demonstrated their ability and interest in both mathematics and physics and feel confident about their scientific abilities. These students should encounter little difficulty in post-secondary physics programs and should be encouraged to pursue careers in which they will utilize their talents in physics. Students who attain a standard of *excellence* show flexibility and creativity when solving

problems, and minor changes in problem format do not cause them major difficulties. They seek general methods to solve problems and are not afraid to use conservation laws. They transfer knowledge from one area of physics to another and can express their answers in clear and concise terms. In addition, these students can connect their understanding of physics to real-world situations that include technological applications and implications beyond the classroom setting. In the laboratory, students who attain a standard of *excellence* can cope with data that are less than perfect or with instructions that are incomplete. These students are capable of defining and calculating quantities such as two-dimensional momentum; current and voltage, using Kirchoff's rules; resistance in series and parallel circuits; the motion of an electric charge in a magnetic field; and variables in the Balmer equation.

Examination Specifications

Each Physics 30 Diploma Examination is constructed as closely as possible to the preceding specifications. Adjustments in the emphasis may be necessary because the exam includes written-response questions and/or machine-scored questions that cover more than one general learner expectation. Questions on the diploma examination will require students to demonstrate knowledge of physics concepts and apply skills in a context that supports making STS connections. A one-hour sample test including a scoring key and sample answers was printed in the 1994–95 Physics 30 Information Bulletin.

The design supports the integration of all Physics 30 general learner expectations as outlined in the *Physics 20–30 Program of Studies, Interim, for Senior High Schools*. As a result, the exam is not necessarily arranged sequentially by units but instead is built around scenarios or contexts that support STS connections.

Examination Specifications (continued)

The 1995 Physics 30 diploma examinations are constructed to place the following approximate emphases on the Physics 30 Course General Learner Expectations.

Knowledge	Emphasis
The student can:	
compare and contrast scalar and vector quantities and fields; apply the concept of field to quantitatively explain, in terms of their source, direction and intensity, the gravitational, electrical, and magnetic effects on objects and systems	10–20%
describe quantitatively, analyze, and predict the behaviour and physical interactions of objects that may be in gravitational, electric, and/or magnetic fields, using the principles of kinematics, dynamics, conservation of energy, momentum, and electric charge, in addition to electrostatics and electromagnetism; apply these principles to atomic theory and other applications	35–45%
explain quantitatively, analyze, and predict the motor/generator effect; describe quantitatively, analyze, and predict the functioning of simple resistive direct current circuits, using Ohm's law and Kirchoff's rules; explain the design, function, and technological applications of simple electric motors, generators, meters, transformers, and other simple electromagnetic devices	10–20%
explain quantitatively the characteristics and behaviours of electromagnetic waves, and algebraically solve problems using the relationship among speed, wavelength, frequency, and energy, and apply these principles with conservation laws to the atomic theory and other applications	25–35%

Skills	Emphasis
The student can:	20–40%
- design, interpret, explain, analyze, and evaluate investigations - organize data into tables, graphs, and diagrams and predict relationships - interpret, explain, analyze, and evaluate data to infer relationships - use appropriate scientific terminology and mathematical language to communicate and explain scientific concepts	

Connections Among Science, Technology, and Society (STS)	Emphasis
The student can:	40–60%
- apply cause-and-effect reasoning to formulate relationships in which scientific evidence shapes or refutes a theory, and explain the limitations of science and technology in answering all questions and solving all problems - describe and evaluate the design and function of technological solutions to theoretical and practical problems using scientific principles and theories, and relate the ways in which science and technology advance one another - evaluate from a variety of perspectives how science and technology are influenced and supported by society, and assess the ability of society to interact responsibly with the environment - apply the skills and knowledge acquired in Physics 30 to everyday life and to related and new concepts in post-secondary studies of physics	

Examination Design

The design of the 1996 Physics 30 diploma examinations is as follows:

<i>Question Format</i>	<i>Number of Questions</i>	<i>Percent Emphasis</i>
Multiple Choice	37	53
Numerical Response	12	17
Written Response	2	30

There has been a change to the Physics 30 Diploma Examinations in the scoring of certain multiple-choice and numerical-response questions. In the past, all multiple-choice and numerical-response questions were developed and scored independent of one another. Now, with the development of more than one question based on the same block of information, a numerical answer from one question may be necessary to complete the calculations in the next question. If students answer the first question incorrectly but use that answer correctly to answer the second question, they will receive full marks for the second question.

To illustrate by example, numerical-response questions 3 and 4 in the January 1995 Physics 30 Diploma examination are of this type. In NR question 3, the student is required to generate a numerical response for the force of attraction between a letter and the toner bead on a photocopier and express it in scientific notation to three digits. Numerical-response question 4 requires the student to then use the answer from NR question 3 to calculate the answer. If the student answers NR question 3 incorrectly but then uses that value to correctly answer NR question 4, the student's response will be marked correct.

A further example, also from the January 1995 Physics 30 diploma examination, linked multiple-choice question 13 and numerical-response question 6. Students could use their recorded answer from MC question 13 to answer NR question 6 correctly, even though their answer to multiple-choice question 13 may have been incorrect.

These variations in answers can be accommodated by the programming designed for electronic scoring.

Other new formats for recording numerical-response answers are shown below. Teachers and students should become familiar and comfortable with the new formats before writing the 1996 Physics 30 Diploma Examination.

Numerical Response

1. Place the following types of EMR in order of increasing energy:

- 1 blue light
- 2 gamma radiation
- 3 radio waves
- 4 ultra violet radiation

(Record your answer on the answer sheet)

Answer:

Use the following information to answer the next question.

Air pollution can be a serious problem in underground parking garages. The quantity of a particular pollutant in the air can be measured by passing a beam of light through the garage and measuring how much of it is absorbed. The light must have a wavelength that is strongly absorbed by the target pollutant.

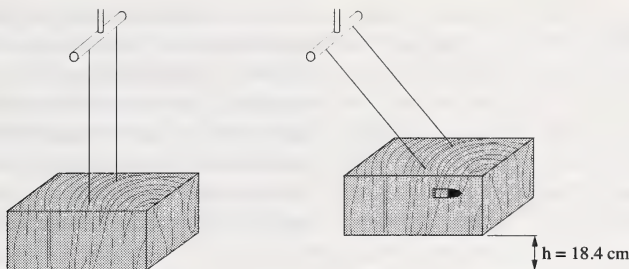
Numerical Response

2. A laser must be designed to supply a wavelength of 164 nm to detect a particular target pollutant. The search for a laser material begins with a list of hydrogen-like atoms/ions. The hydrogen-like atom whose 3-2 transition would emit light at 164 nm would have an E_1 value, expressed in scientific notation, of $-a.b \times 10^{-cd}$ J.

(Round and record your answer as)

Answer:

Use the following information to answer the next question.



A ballistic pendulum is a device used to measure the speeds of fast moving objects like bullets. It consists of a wooden block with a mass of 1.00 kg.

A bullet with a mass of 5.00 g is fired from a gun with a barrel that is 74.2 cm long. The gun's mass is 2.45 kg. When the bullet strikes the block, it causes the block to rise to a height of 18.4 cm.

Numerical Response

3. The speed of the bullet just before it strikes the ballistic pendulum, expressed in scientific notation, is $a.bc \times 10^d$ m/s.

(Round and record your answer as .)

Answer:

Numerical Response

4. Light is incident on the surface of a metal that has a work function of 2.40 eV. The kinetic energy of the ejected photoelectrons is 5.00 eV. The same radiation is incident on a second surface that has a work function of 4.20 eV. The ratio of the kinetic energy of the photoelectrons from the first surface to the second surface is $b:1$. The value of b is _____.

(Round and record your answer to three digits.)

Answer: 1.56

Assessment of STS Connections

Students' understanding of the concepts of science are measured by every question on the examinations. In addition, some questions measure the students' understanding and use of skills associated with scientific inquiry. Some questions have been designed to measure the students' understanding of the connections between science and technology and among science, technology, and society. As a result, many questions measure how well students can apply the skills and knowledge they have acquired in science to everyday life.

Assessment of Communication Skills

Communication skills are assessed most directly in the teacher-scored questions. For the open-response questions, the descriptions used in the holistic scoring guides may include criteria for assessing communication skills along with criteria for the other components. Examples of scoring criteria can be found on pages 20 and 21.

The term *communication skills* includes those processes by which information is exchanged through appropriate conventions. These conventions include:

- words, sentences, paragraphs
- graphs, diagrams
- mathematical formulas, mathematical and chemical equations
- significant digits, units of measurement

Conventions that are considered appropriate for a particular response are subject- and question-specific.

One-Marker Scoring System

Each Physics 30 Diploma Examination has two written-response questions, one of which is a closed-response question. The students' answers to this question are scored by one teacher using an analytic scoring guide. Each guide lists criteria required for each mark along with a sample response that meets all the criteria for a score of 10. For an example of this type of question and sample answers, see pages 14 to 17. Another example of this type of question can be found in 1995 June Diploma Examination, written-response question 2.

Two-Marker Scoring System

The other written-response question is an open-response question. Students' answers to the open-response question are scored by teachers using holistic scoring guides. The guides describe the characteristics of students' answers that correspond to one of five values—0, 1, 2, 3, or 4 for the physics content used to solve the problem, and one of four values: 0, 1, 2, or 3 for the effective communication of the response. Each student's answer is scored independently by two teachers. The two content scores are added together for a combined total sub-score out of 8, while the two communication scores are averaged for a sub-score out of 3. The two sub-scores are added together for a total out of 11.

If the scores obtained by the two independent readings represent a difference of 2 or more scale categories on the guides, the scores are classified as *discrepant*. Student responses that have *discrepant* scores are read by a third reader. The third reader will assign a score that is within the limits established by the discrepant scores of the first two readers. The content score will be multiplied by 2 for a total sub-score out of 8. The communication score, out of 3, will be added to the content score for a maximum of 11.

A summary of the calculations follows:

Content: Reader 1 Score (X out of 4) + Reader 2 Score (X out of 4) = Sub-score (X out of 8)

Communication: Reader 1 Score (X out of 3) + Reader 2 Score (X out of 3) divided by 2 = Sub-score (X out of 3)

Final score = Content (X out of 8) + Communication (X out of 3)

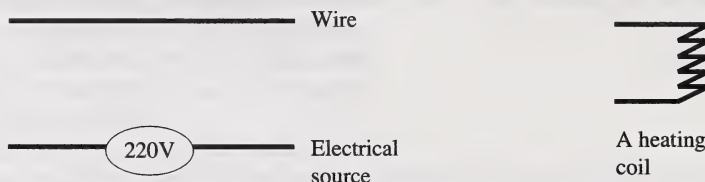
For an example of this type of question and sample answers, see pages 18 to 25. Another example of this type of question can be found in the 1995 June Diploma Examination, written-response question 1.

Scoring of Sample Answers

Written-Response Question 1, January 1995

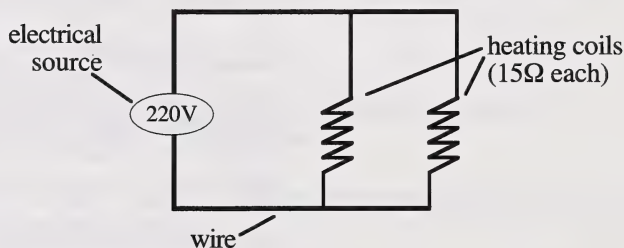
Use the following information to answer the next question.

Hot water in a domestic residence is produced by heating water in a tank. The heating source in many hot water tanks is provided by 220 V electrical coils that are placed in the tank. Each of the electrical coils has a resistance of $15\ \Omega$.



1. a. Using the symbols above, draw the circuit diagram that would use two coils to heat the water in the shortest possible time.

Parallel Circuit



There are **two** marks for this part:

- one mark for drawing a circuit (must have two coils and an electrical source) and labelling the diagram using either words or numerical values
 - one mark for placing the heating coils in parallel
- b. What current is provided by the 220 V source to the two heating coils?

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R} = \frac{1}{15} + \frac{1}{15}$$

$$R = 7.5\ \Omega$$

$$V = IR \quad I = \frac{V}{R}$$

$$I = \frac{220 \text{ V}}{7.5 \Omega} = 2.93 \times 10^1 \text{ A}$$

$$I = 29 \text{ A}$$

There are **two** marks for this part:

- one mark for stating $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ or equivalent (Kirchoff) and either calculating $R = 7.5 \Omega$ or stating 7.5Ω
- one mark for stating $V = IR$ or equivalent and calculating an answer $I = 29 \text{ A}$

c. What is the power consumed by each heating coil?

Current through each coil is half the total current.

$$P = VI$$

$$= (220 \text{ V}) \left(\frac{29.3 \text{ A}}{2} \right)$$

$$P = 3.2 \times 10^3 \text{ W}$$

There are **two** marks for this part:

- one mark for dividing either the total current in the circuit or the total power produced by both coils by two or equivalent
- one mark for stating $P = VI$ or equivalent and calculating an answer $P = 3.2 \times 10^3 \text{ W}$

Use this additional information to answer the next question.

The amount of energy needed to heat water is given by the formula $E = mc\Delta T$, where m is the mass of water, c is the specific heat capacity of water, and ΔT is the change in temperature. The specific heat of water is $4.2 \times 10^3 \text{ J}/(^{\circ}\text{C}\cdot\text{kg})$.

d. How long in minutes will it take the two heating coils to raise the temperature of a tank containing 160 kg of water by 1.0°C ? (If you were unable to determine the amount of consumed power in part c, use the hypothetical value $P = 3.55 \times 10^3 \text{ W}$.)

Energy needed to heat water

$$E = mc\Delta T$$

$$E = (160 \text{ kg}) \left(\frac{4.2 \times 10^3 \text{ J}}{\text{C kg}} \right) (1.0 \text{ C})$$

$$E = 6.72 \times 10^5 \text{ J}$$

Power produced by two coils

Using rounded values

$$P = VI$$

$$P = (29 \text{ A}) (220 \text{ V})$$

$$P = 6.38 \times 10^3 \text{ W}$$

Using intermediate values

$$P = VI$$

$$P = (29.333333 \text{ A}) (220 \text{ V})$$

$$P = 6.4533333 \times 10^3 \text{ W}$$

Time needed to heat water

$$P = \frac{W}{t} \quad \text{work} = \text{energy needed}$$

$$P = \frac{E}{t}$$

$$t = \frac{E}{P}$$

$$t = \frac{(6.72 \times 10^5 \text{ J})}{(6.38 \times 10^3 \text{ W})}$$

$$t = 1.0532915 \times 10^2 \text{ s}$$

$$t = \left(1.0532915 \times 10^2 \text{ s} \right) \left(\frac{1 \text{ min}}{60 \text{ s}} \right)$$

$$t = 1.7554858 \times 10^0 \text{ min}$$

$$t = 1.8 \text{ min}$$

Using intermediate values

$$t = \frac{(6.72 \times 10^5 \text{ J})}{(6.4533333 \times 10^3 \text{ W})}$$

$$t = 1.0413223 \times 10^2 \text{ s}$$

$$t = \left(1.0413223 \times 10^2 \text{ s} \right) \left(\frac{1 \text{ min}}{60 \text{ s}} \right)$$

$$t = 1.7355371 \times 10^0 \text{ min}$$

$$t = 1.7 \text{ min}$$

Special Case

Using the hypothetical value $P = 3.55 \times 10^3 \text{ W}$

$$t = \frac{(6.72 \times 10^5 \text{ J})}{2(3.55 \times 10^3 \text{ W})}$$

$$t = 9.4647887 \times 10^1 \text{ s}$$

$$t = \left(9.4647887 \times 10^1 \text{ s}\right) \left(\frac{1 \text{ min}}{60 \text{ s}}\right)$$

$$t = 1.5774647 \times 10^0 \text{ min}$$

$$t = 1.58 \text{ min}$$

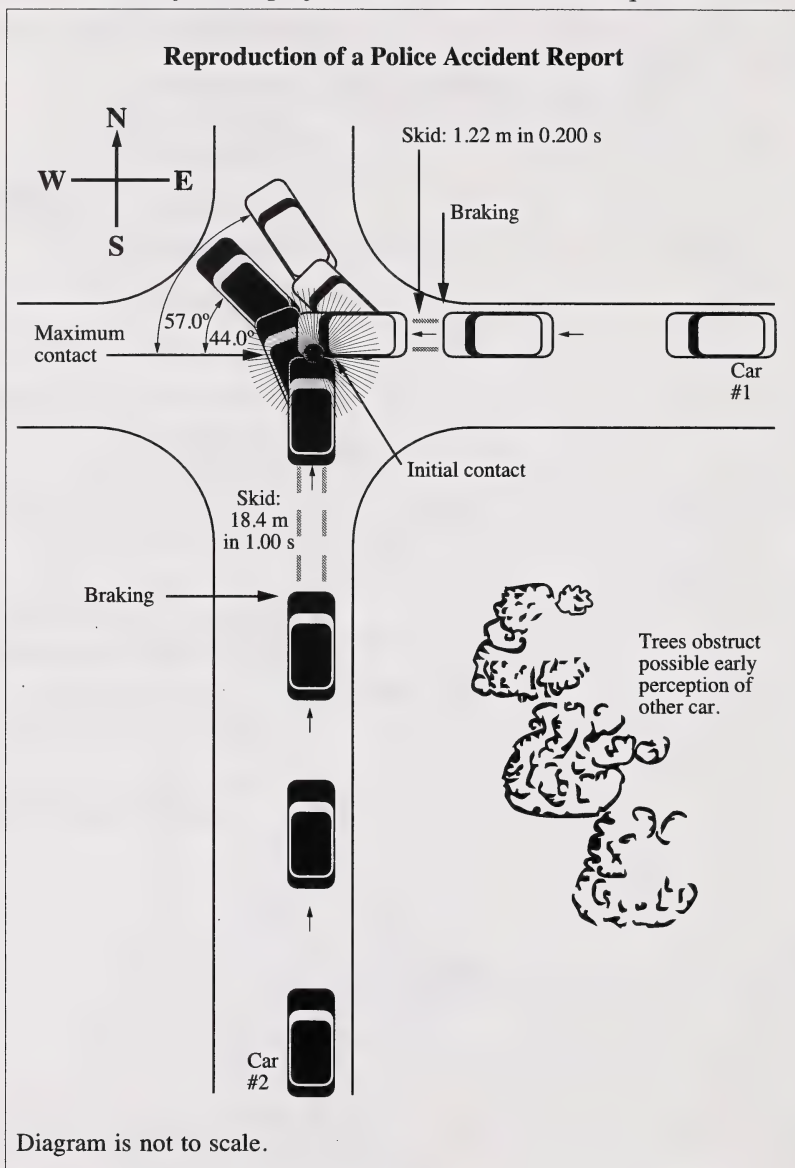
There are **four** marks for this part:

- one mark for correct substitution into $E = mc\Delta T$ and calculating $E = 6.72 \times 10^5 \text{ J}$
- one mark for stating $P = VI$ and calculating $P = 6.38 \times 10^3 \text{ W}$ (or using intermediate values $P = 6.4533333 \times 10^3 \text{ W}$)
- one mark for stating $P = \frac{E}{t}$ or equivalent and calculating $t = 1.0532915 \times 10^2 \text{ s}$ (or using intermediate values $t = 1.0413232 \times 10^2 \text{ s}$)
- one mark for converting to $t = 1.8 \text{ min}$ (or using intermediate values $t = 1.7 \text{ min}$)

Note: Also, if the solution uses the hypothetical value of $P = 3.55 \times 10^3 \text{ W}$, the second mark cannot be awarded.

Written-Response
Question 2, January 1995

Use the following information to answer the next question.



2. After measuring and evaluating skid marks, police were able to determine that Car #1, of mass 765 kg, was travelling at 70.0 km/h just after the impact. Car #2, of mass 1100 kg, was determined to be moving at 41.0 km/h just after impact. In analyzing this accident scene, it is important for police to establish the velocity of each car just before impact.

Describe in detail and show how the police investigator would calculate the velocities of both cars just before collision.

Note: A maximum of 8 marks will be awarded for the physics used to solve this problem. A maximum of 3 marks will be awarded for the effective communication of your response.

Written-Response Question 2—Holistic Scoring Guide Reporting Category: Physics CONTENT

When marking **CONTENT**, the marker should consider how effectively the response uses physics concepts, knowledge, and skills to **show how** the police investigator would calculate the velocities of both cars just before collision.

Score	Criteria
4 Standard of Excellence (80%)	The response: - addresses the major concept of conservation of momentum - uses an appropriate strategy that reflects thorough understanding of the two-dimensional aspect of the problem where the x and y components of the resultant momentum are clearly recognized as being the initial momentum of car 1 and 2 - correctly uses momentum formula and trigonometric functions; minor errors in substitution and/or calculation of the velocity may be present - may provide the velocity of each car just before collision that is consistent with their strategy (consider significant digits, units; direction may be inferred)
3	The response: - addresses the major concept of conservation of momentum - uses an appropriate strategy that reflects a good understanding of the two-dimensional aspect of the problem where the x and y components of the resultant momentum may be inferred as being the initial momentum of Car 1 and 2. - correctly uses momentum formula, however, either the incorrect use of the trigonometric functions and/or errors in substitution and calculation may be present - may provide the velocity of each car just before collision that may be inconsistent with their strategy

2 Acceptable Standard (50%)	The response: - addresses the major concept of some conservation of momentum - uses a strategy that reflects an understanding of the two-dimensional aspect of the problem; may not recognize the x and y components of the resultant momentum as being the initial momentum of Car 1 and 2 - correctly uses momentum formula, however, use of the trigonometric functions are either incorrect or incomplete, as well errors in substitution and calculation are present - may provide the velocity of each car just before collision that may be inconsistent with their strategy
1	The response: - may indirectly address the major concept of the conservation of momentum - uses a strategy that reflects little or no understanding of the two-dimensional aspect of the problem; the strategy used may treat the problem as one-dimensional - may use momentum formula, however, the use may be inappropriate or incomplete as well substitution into formula may be flawed - provides momentums of the cars but may fail to solve for the velocities just before impact
0	The response: - shows little or no evidence that momentum is conserved - uses a strategy that is inappropriate or there is little or no evidence of a strategy - does not provide momentums or velocities of the cars
NR	No response is given.

Written-Response Question 2—Holistic Scoring Guide Reporting Category: Physics COMMUNICATION

When marking **COMMUNICATION**, the marker should consider how effectively the response **describes in detail how** the police investigator would calculate the velocities of both cars just before collision.

Score	Criteria
3 Excellent (80%)	The response: - is complete, well organized and the explanation of the solution is relevant, appropriate, and clear - describes in detail the strategy in a logical manner demonstrating consistency of thought - uses physics vocabulary appropriately and a precise, explicit relationship exists between the explanation and diagrams - explicitly states momentum formula if used - may have a mathematical error present, but it does not hinder the understanding of either the strategy or the solution

2 Satisfactory	The response: • is organized and in the attempt to explain the solution is appropriate, however, errors sometimes affect the clarity of the explanation • describes the strategy but details are general and/or sometimes lacking, leaving it somewhat open to interpretation • uses physics vocabulary, however, it is sometimes misused; and an implicit relationship exists between explanation and diagrams (if used) • formula may be inferred by analyzing the calculations • likely has mathematical errors present that may hinder the understanding of either the strategy or the solution
1 Poor	The response: • lacks organization and in their attempt to explain all aspects of the problem is not evident and errors may be present that affect the clarity of the explanation • describes a strategy that provides little or no detail • uses physics vocabulary, however, it is often misused and there is weak relationship between the explanation and diagrams (if used) • may not state the formula, however, it is likely that it can be inferred by analyzing the calculations • may have mathematical errors that hinder the understanding of the strategy and/or the solution
0	The response: • is not organized and there is little or no attempt to explain any aspect of the problem • does not describe a strategy to solve the problem • uses little or no physics vocabulary, however, if present, it is misused and there is no relationship between the explanation, if present, and diagrams (if used) • may state formula but it does not contribute towards the solution • is confusing and/or frustrating to the reader • has very little written
NR	No response given.

Communication Score—3

Rationale: The response is well organized and the explanation is relevant and clear. Although the conversion from Km/h to m/s is omitted, this omission does not hinder the understanding of either the strategy or the solution. The explanation is consistent in thought, uses physics vocabulary well, and states the equations and formulas to be used. The treatment of significant digits is inconsistent, but again it does not take away from the communication of the response.

Content Score—4

Rationale: The response addresses the major concept of conservation of momentum. The explanation describing the vector components of velocity and the trigonometric functions indicate a thorough understanding of the two-dimensional aspect of the problem. Use of all formulas is correct, and the answer is consistent with the strategy used.

The Masses of both cars can be determined empirically. Knowing the velocity of each car after the collisions, equations can be set up:

For Car 1 $V_f \cdot \cos \Theta$ and $V_f \cdot \sin \Theta$ will yield horizontal and vertical components of velocity,
for Car 2 $V_f \cdot \cos \Theta$ and $V_f \sin \Theta$

Putting in numbers

$$\text{Car 1: } 19.5 \text{ m/s} \cdot \cos 57.0^\circ = 10.6 \text{ m/s } V_H, \\ 19.5 \text{ m/s} \cdot \sin 57.0^\circ = 16.4 \text{ m/s } V_V,$$

$$\text{Car 2 } 11.4 \text{ m/s} \cdot \cos 44.0^\circ = 8.19 \text{ m/s } V_{H_2} \\ 11.4 \text{ m/s} \sin 44.0^\circ = 7.92 \text{ m/s } V_{V_2}$$

From conservation of momentum

$$E_{p_i} = E_{p_f}$$

$$P_{fv} = (16.4 \text{ m/s}) \cdot (765 \text{ Kg}) + (7.92)(1100 \text{ Kg})$$

$$P_{fv} = 21258 \text{ Kg} \cdot \text{m/s}$$

$$P_{fH} = (10.6 \text{ m/s}) \cdot (765 \text{ Kg}) + (8.19 \text{ m/s}) \cdot (1100 \text{ Kg}) \\ = 17118 \text{ Kg} \cdot \text{m/s}$$

Because Car₁ was travelling horizontally it has no vertical momentum. ∴

$$17118 \text{ Kg} \cdot \text{m/s} = (765 \text{ Kg}) \cdot V \\ V = 22.4 \text{ m/s}$$

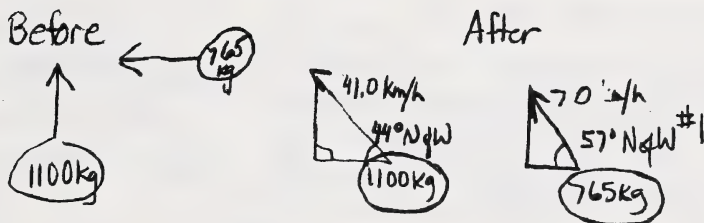
$$\text{Car 2 } \therefore, \text{ has no horizontal momentum} \\ 21258 \text{ Kg} \cdot \text{m/s} = (1100 \text{ Kg}) V \\ V = 19.32 \text{ m/s}$$

Car₁ was going 80.64 Kph

Car₂ was going 69.552 Kph

Communication Score—2

Rationale: The response is complete and organized in an attempt to explain the solution; however, errors such as the use of m and v hinder the understanding of the explanation. Confusion also arises when calculations for the x and y component of the final velocities appear after they have been inserted into the conservation of momentum formula. In addition, units for velocities flip back and forth with no explanation, again hindering the reader's understanding of the solution.



Total momentum before a collision must always equal the total momentum after a collision. The police ~~can~~ could of used this principle to deduce the velocities of cars 1 and 2 before the collision.

$$\# m_1 v_1 + m_2 v_2 = \text{after } m_1 v_{1x} + m_1 v_{1y} + m_2 v_{2x} + m_2 v_{2y}$$

$$1100 \text{ kg} (v_x) + 765 \text{ kg} (v_y) = 765 \text{ kg} (38.1 \text{ m/s}) + 765 \text{ kg} (58.7 \text{ m/s}) + 1100 \text{ kg} (29.5 \text{ m/s}) + 1100 \text{ kg} (28.5 \text{ m/s})$$

$$\text{Car \#1} \\ \sin 57^\circ = \frac{y}{7.0}$$

$$y = 58.7$$

$$\cos 57^\circ = \frac{x}{7.0}$$

$$x = 38.1$$

$$\text{Car \#2} \\ \sin 44^\circ = \frac{y}{4.1}$$

$$y = 28.5$$

$$\cos 44^\circ = \frac{x}{4.1}$$

$$x = 29.5$$

$$1100 \text{ kg} (v_x) = 765 (38.1 \text{ m/s}) + 1100 \text{ kg} (29.5 \text{ m/s})$$

$$765 \text{ kg} (v_y) = 765 (58.7 \text{ m/s}) + 1100 \text{ kg} (28.5 \text{ m/s})$$

$$1100 \text{ kg} (v_x) = 29146.5 \text{ kg m/s} + 32450 \text{ kg m/s}$$

$$\text{The } v \text{ of car \#2 before the collision was } 56.0 \text{ km/h (Car \#2)}$$

$$765 \text{ kg} (v_y) = 44905.5 \text{ kg m/s} + 31350 \text{ kg m/s}$$

$$\text{The } v \text{ of car \#1 before the collision was}$$

$$99.7 \text{ km/h. (Car \#1)}$$

By examining the x and y components of the cars momentums after the collision, the police would be able to determine the velocity of the cars before they collide. This is possible because the total momentum before a collision must equal the total momentum after.

Content Score—3

Rationale: The response addresses the conservation of momentum. This is supported by the use of diagrams, formulas, equations, and trigonometric functions. Minor errors appear in the equation used to calculate the momentum of the cars after collision. A major error occurs when the masses of Car 1 and Car 2 are substituted for each other throughout all calculations. In addition, units are substituted into the equation incorrectly. Minor mathematical errors in computation provide an inaccurate answer to an appropriate strategy.

Communication Score—1

Rationale: The lack of organization and the errors in the response affect the clarity of the brief explanation. The description of the strategy provides little detail, and there is a weak link between the diagram and the explanation. Some formulas are present, and equations can be inferred by analyzing the calculations.

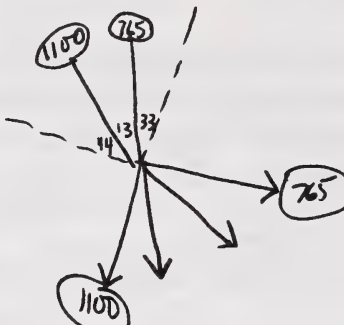
Content Score—2

Rationale: The response addresses the major concept of the conservation of momentum by stating the equation $P_a = P_b$. The strategy recognizes the two-dimensional aspect of the problem, as indicated by the diagram and by the use of trigonometry functions. For the most part, formulas are used appropriately. However, the misuse of the trigonometry formula is evidence of a weak understanding of the mathematics needed to arrive at an acceptable answer. Speeds of the cars just before impact are consistent with the strategy.

$P_a = P_b$

$\frac{70 \text{ km}}{h} = 19.44 \text{ m/s}$

$P = mv$



$\tan \theta = \frac{765}{1100}$

$\theta = 34.8$

$P_a = 765(70) + 1100(41)$
 $= 98650 \text{ kg m/s}$

$m_1 u_1 = 765(70) = 765 \sin 34.8 u_1$
 $u_1 = 1.23 \times 10^2 \text{ m/s}$

$m_2 u_2 = 1100(41) = 1100 \cos 34.8 u_2$
 $u_2 = 7.48 \times 10^1 \text{ m/s}$

Communication Score—2

Rationale: The response is presented in a manner that is easy to follow. It uses a combination of sentences, formulas, equations, mathematics, and a list of some of the information relevant to the solution presented. The strategy lacks detail, leaving the reader to fill the gaps. The response leads the reader into believing that substitution into the momentum formula will provide the speeds of Cars A and B. However, this never happens. Instead, the reader must make the link between the calculation and the closing statement. The solution is incomplete.

$$\begin{aligned}m_A &= 765 \text{ Kg.} \\V_A' &= 70.0 \text{ Km/hr.} \\m_B &= 1100 \text{ Kg.} \\V_B' &= 41.0 \text{ Km/hr.}\end{aligned}$$

Because the conservation of momentum the sum of the momenta of cars A+B before will be equal to the sum of the cars A+B after, (P_A') = momentum of car A after collision.

$$\begin{aligned}V_A' &= 70.0 \frac{\text{Km}}{\text{hr}} \times \frac{\text{hr}}{3600\text{s}} \times \frac{1000\text{m}}{1\text{Km}} & V_B' &= 41.0 \frac{\text{Km}}{\text{hr}} \times \frac{\text{hr}}{3600\text{s}} \times \frac{1000\text{m}}{1\text{Km}} \\&= 19.4 \text{ m/s.} & &= 11.39 \text{ m/s.}\end{aligned}$$

$$P_A + P_B = P_A' + P_B' \text{ because } p = mv$$

$$\begin{aligned}\text{Therefore } m_A V_A + m_B V_B &= m_A V_A' + m_B V_B' \\(765 \text{ Kg} \times V_A) + (1100 \text{ Kg} \times V_B) &= (765 \text{ Kg} \times 19.4 \text{ m/s}) + (1100 \text{ Kg} \times 11.39 \text{ m/s}) \\&= 14841 \text{ Kg} \cdot \text{s} + 12529 \text{ Kg} \cdot \text{s} \\&= 27370 \text{ Kg} \cdot \text{s.}\end{aligned}$$

Content Score—1

Rationale: The response does address the major concept of conservation of momentum, which is stated in words and in equation form. However, the strategy used reflects no understanding of the two-dimensional aspect of the problem; it uses a one-dimensional approach instead. Momentums of the cars after impact are determined; however, the student fails to use this information to calculate the speed of each car before impact.

Because the momentum after the collision was 27370 Kg m/s we know because all momentum is conserved that the momentum before is 27370 Kg m/s.

Calculator Policy

POLICY: USE OF CALCULATORS ON ALBERTA EDUCATION DIPLOMA EXAMINATIONS

Background

The knowledge, skills, and attitudes relevant to technology and its uses are being incorporated into courses and programs of study wherever appropriate. Students are expected to learn the advantages and limitations of technological developments and their impact upon society. The ability to use technology helps students understand and appreciate the process of technological change, gives added depth to programs, and provides the basis for the development of skills and understanding. These expectations are reflected in the diploma examinations. Since the data provided for writing diploma examinations in mathematics and the sciences do not include information such as logarithms and trigonometric functions, students will need to use scientific calculators for these exams.

Definition

This policy considers a scientific calculator to be a hand-held device designed primarily for mathematical computations. Included in this definition are those scientific calculators having graphing capabilities, built-in formulas, mathematical functions, or other programmable features.

Policy

To ensure compatibility with provincial *Programs of Study* and equity and fairness for all students, Alberta Education expects students to use scientific calculators, as defined above, when they are writing diploma examinations in mathematics and the sciences. Examinations are constructed to ensure that the use of particular models of calculators neither advantages nor disadvantages individual students.

Procedures

1. Teachers must, at the beginning of a course, advise students of the types of calculators that they may use when writing diploma examinations in mathematics and the sciences. Teachers must also advise students of the types of information that can be stored in calculators that are brought into diploma examinations. Calculators that have built-in notes (definitions or explanations in alpha notation) that cannot be cleared are not permitted.
2. Students must clear calculators that are brought into diploma examinations of all information they have stored except for
 - a. programs used for computing values of the formulas on the diploma examination data tear-out pages or in the data booklets,
 - b. programs used for graphing quadratic relations as found in the Mathematics 30/33 Interim Teacher Resource Manual.
3. Students must not bring external devices to support calculators into the exam. Such devices include manuals, printed or electronic cards, printers, memory expansion chips or cards, external keyboards, or any annotations outlining operational procedures for scientific calculators.
4. In preparation for calculator failure, students may bring extra calculators and batteries into the exam room.
5. During exams, supervising teachers must ensure that
 - a. all calculators operate in silent mode,
 - b. students do not share calculators or information contained within them,
 - c. calculator cases are stored on the floor throughout the exam, and
 - d. all examination rules are followed.
6. If you have any questions or comments about the implementation of this policy, please contact the Math/Science Unit, Student Evaluation Branch, at 403-427-0010 or FAX 403-422-4200.

Examination Rules

GRADE 12 DIPLOMA EXAMINATIONS

Appendix B

1. **Admittance to the Examination Room**

Students must not enter or leave the examination room without the consent of the supervising teacher.

2. **Student Identification**

Students must present identification that includes their signature and photograph. One of the following documents is acceptable: driver's licence, passport, or student identification card. Students must not write an examination under a false identity or knowingly provide false information on an application form.

3. **Identification on Examinations**

Students must not write their names or the name of their school anywhere in or on the examination booklet, other than on the back cover.

4. **Time**

Students must write an examination during the specified time and may not hand in a paper until at least one hour of the examination time has elapsed. Students who arrive more than one hour after an examination has started will not be allowed to write the examination. Students who arrive late but within the first hour of an examination sitting may be allowed to write only at the discretion of the supervising teacher.

5. **Discussion**

Students must not discuss the examination with the supervising teacher unless the examination booklet is incomplete or illegible. Students must not talk, whisper, or exchange information with one another.

6. **Answer Sheets**

Students must use an HB pencil to record their answers on the machine-scorable answer sheets.

7. **Materials Allowed:**

• **English 30, English 33:**

For Part A only, all students may use a print or electronic dictionary (English language or translation), a thesaurus, and an authorized writer's handbook (for example: *The Canadian Writer's Handbook*, Prentice Hall).

• **Français 30:**

For Partie A only, all students may use a print or electronic dictionary (French language or translation), a thesaurus, and a book of verb forms/tenses.

• **Biology 30, Mathematics 30, Physics 30:**

Tear-out data pages are provided in the examination booklets. Students need to use scientific calculators, but must not share them.

• **Chemistry 30, Mathematics 33, Science 30:**

Students must use the separate data booklet provided for each of these examinations. Students need to use scientific calculators, but must not share them.

• **All mathematics and science examinations:**

Students may use calculator programs designed to perform mathematical computations and/or those designed to assist students in graphing.

8. **Materials Not Allowed:**

• **All Subjects:**

Students must not bring any papers, notes of any kind, books (other than those allowed, see #7) into the examination room. Students must ensure that dictionaries (print and electronic), references, and calculators are completely free of notes or study material.

• **Biology 30, Chemistry 30, Mathematics 30, Mathematics 33, Physics 30, Science 30, Social Studies 30, Social Studies 33:**

Reference materials and dictionaries (translation, English and/or French language) are not allowed.

Appendix C

Guidelines for Significant Digits, Manipulation of Data, and Rounding in the Mathematics and Sciences Diploma Examinations

Significant Digits

1. For all non-logarithmic values, regardless of decimal position, any of the digits 1 to 9 is a significant digit; 0 may be significant. For example:

123 0.123 0.00230 2.30×10^3
all have 3 significant digits
2. Leading zeros are not significant. For example:

0.12 and 0.012 each have two significant digits
3. Trailing zeros to the right of the decimal are significant. For example:

0.123 00 and 20.000 each have five significant digits
4. Zeros to the right of a whole number are considered to be ambiguous. **The Student Evaluation Branch considers all trailing zeros to be significant.** For example:

200 has three significant digits
5. For logarithmic values, such as pH, any digit to the left of the decimal is **not** significant. For example:

a pH of 1.23 has two significant digits
a pH of 7 has no significant digits

Manipulation of Data

1. When adding or subtracting measured quantities, the calculated answer should be rounded to the same degree of precision as that of the least precise number used in the computation **if this is the only operation.** For example:

12.3 (least precise)
0.12
12.34
24.76

The answer should be rounded to 24.8.

2. When multiplying or dividing measured quantities, the calculated answer should be rounded to the same number of significant digits as are contained in the quantity with the fewest number of significant digits **if this is the only operation**. For example:

$$(1.23)(54.321) = 66.81483$$

The answer should be rounded to 66.8.

3. When a series of calculations is performed, each interim value should not be rounded before carrying out the next calculation. The final answer should then be rounded to the same number of significant digits as are contained in the quantity in the original data with the fewest number of significant digits. For example:

In determining the value of $(1.23)(4.321)/(3.45 - 3.21)$, three calculations are required:

- a. $3.45 - 3.21 = 0.24$
 - b. $(1.23)(4.321) = 5.31483$
 - c. $5.31483/0.24 = 22.145125$
- [Not $5.31/0.24 = 22.125$]

The value should be rounded to 22.1.

Note: In the example given, steps *a* and *b* yield interim values. These values should not be used in determining the number of significant digits.

Rounding

1. When the first digit to be dropped is less than or equal to 4, the last digit retained should not be changed. For example:

1.2345 rounded to three digits is 1.23

2. When the first digit to be dropped is greater than or equal to 5, the last digit retained should be increased by one. For example:

12.25 rounded to three digits is 12.3

Appendix D

Explanations of Cognitive Levels

Knowledge refers to those behaviours and test situations that emphasize the remembrance, either by recognition or recall, of ideas, material, or phenomena.

Comprehension refers to responses that demonstrate an understanding of the literal message contained in a communication.

Application requires the student to apply an appropriate abstraction (theory, principle, idea, method) to a new situation.

Analysis comprises the ability to recognize unstated assumptions, to distinguish facts from hypothesis, to distinguish a conclusion from statements that support it, to recognize facts or assumptions that are essential to a main thesis, to distinguish cause–effect relationships from other sequential relationships, and to recognize a writer’s viewpoint.

Synthesis is the production of a unique communication. It is the ability to propose ways of testing hypotheses, the ability to design an experiment, the ability to formulate and modify hypotheses, and the ability to make generalizations.

Evaluation is defined as making judgements about the value of ideas, solutions, and methods. It involves the use of criteria to appraise the extent to which details are accurate, effective, economical, or satisfying. Evaluation includes the ability to apply given criteria to judgements of work done, to indicate logical fallacies in arguments, and to compare major theories and generalizations.

Directing Words

Discuss

The word “discuss” will not be used as a directing word on math and science diploma examinations because it is not used consistently to mean a single activity.

The following words are specific in meaning. The corresponding cognitive levels are enclosed in parentheses.

Contrast/Distinguish

Point out the *differences* between two things that have similar or comparable natures. (Analysis)

Compare

Examine the character or qualities of two things by providing characteristics of both that point out their mutual *similarities* and *differences*. (Analysis and/or Evaluation)

Conclude

State a logical end based on reasoning and/or evidence. (Evaluation)

Criticize

Point out the *merits* and *demerits* of an item or issue. (Analysis and Evaluation)

Define

Provide the essential qualities or meaning of a word or concept. Make distinct and clear by marking out the limits. (Knowledge)

Describe

Give a written account or represent the characteristics of something by a figure, model, or picture. (Knowledge)

Design/Plan

Construct a plan, i.e., a detailed sequence of actions, for a specific purpose. (Application and/or Synthesis)

Enumerate

Specify one by one or list in concise form and according to some order. (Knowledge)

Evaluate

Give the significance or worth of something by identifying the good and bad points or the advantages and disadvantages. (Analysis and Evaluation)

Explain

Make clear what is not immediately obvious or entirely known; give the cause of or reason for; make known in detail. (Comprehension)

How

Show in what manner or way, with what meaning. (Comprehension)

Hypothesize

Form a tentative proposition intended as a possible explanation for an observed phenomenon; i.e., a possible cause for a specific effect. The proposition should be testable logically and/or empirically. (Analysis and Synthesis)

Identify

Recognize and select as having the characteristics of something. (Knowledge)

Illustrate

Make clear by giving an example. The form of the example must be specified in the question; i.e., word description, sketch, or diagram. (Comprehension and/or Application)

Infer

Form a generalization from sample data; arrive at a conclusion by reasoning from evidence. (Evaluation)

Interpret

Tell the meaning of something, present information in a new form that adds meaning to the original data. (Comprehension)

Justify/Show How

Show reasons for or give facts that support a position. (Evaluation)

Outline

Give, in an organized fashion, the essential parts of something. The form of the outline must be specified in the question; i.e., lists, flow charts, concept maps. (Knowledge and/or Comprehension)

Predict

Tell in advance on the basis of empirical evidence and/or logic.
(Application)

Prove

Establish the truth, validity, or genuineness of something by giving factual evidence or logical reasons. (Evaluation)

Relate

Show logical or causal connection between things. (Analysis)

Solve

Give a solution for a problem; i.e., explanation in words and/or numbers.
(Analysis and Synthesis)

Summarize

Give a brief account of the main points. (Comprehension)

Trace

Give a step-by-step description of the development. (Knowledge)

Why

Show the cause, reason, or purpose. (Comprehension and/or Synthesis)

Appendix E

Preparing to Write a Science Diploma Examination—What every student should do before the examinations!

1. Prepare a course review schedule:
 - design your schedule for the two-week period (minimum) before the examination
 - divide the course material into sections and indicate on the schedule the time blocks to be devoted to each section
 - take into account the examination blueprint available from your teacher (*Diploma Examinations Program Information Bulletin* for the course). Note that course units are not equally weighted on the diploma examination
 - take into account units/concepts that you find most difficult; i.e., allocate more time for the review of these
2. Obtain and review examination schedules, rules, and policies:
 - record the time and place of writing
 - note minimum and maximum writing times permitted
 - prepare to remain in the examination room for at least 2.5 h (Kleenex, cough drops, etc.)
 - identify materials allowed for writing each examination, such as pencils, pens, calculators, mathematical instruments, and clear plastic ruler
3. Identify and collect examples of each type of question that will be asked:
 - obtain a copy of the relevant information contained in the *Diploma Examinations Program Information Bulletin* for the course (available from your teacher)
 - review the format of previous diploma examinations (available from your teacher)
 - learn the meanings of key “directing” words such as compare, describe, evaluate, explain, illustrate, interpret, justify, prove, and solve
4. Make summaries and point form outlines:
 - distinguish between major concepts and factual details
 - identify essential skills that can be assessed on paper and pencil tests
 - review lab results and procedures— identify connections between lab reports, class notes, and textbook
 - anticipate examples of connections between concepts and the “real world”
 - prepare a glossary of important subject terminology
 - review the data booklet for Chemistry 30 or Science 30, or the data tear-out pages for Biology 30 or Physics 30, and review formulas and equations if applicable
 - link each formula or equation with a calculation done on a previous test or assignment
 - identify any restriction on the use of each formula or equation
5. Use memory aids such as:
 - colour coding, underlining, highlighting, jotting key words in margins
 - numbering points to be memorized
 - grouping word and idea associations
 - reading aloud key words, expressing key words in your own words
6. Review the different question formats and the instructions on how to answer these questions.

Appendix F

Suggestions for Students When Writing Science Diploma Examinations—What every student should know when writing examinations!

1. Do not be afraid to answer each question even if you are not sure of the correct solution to the problem. A penalty is NOT given for guessing on the machine-scored section the exam. Partial marks are often awarded for incomplete answers in the written-response section of the exam.
2. If you are stuck on a question, mark the alternatives that you know are incorrect and choose from the ones that are left, using logical guessing strategy. Think of the questions as challenges and cultivate a positive attitude about your ability to answer them.
3. Scan the sets of questions of the examination before answering a particular question. The questions in one set of the examination may jog your memory about a question in another set.
4. When first reading a multiple-choice question, locate and circle key words to help clarify the meaning of the question. Then hide the alternatives and try to formulate an answer of your own. Your answer may be very close to the correct alternative.
5. If a multiple-choice question involves a calculation, do the calculation and select the alternative that is closest to your answer. A multiple-choice calculation is usually short. If you cannot do it in five minutes, your method is either inappropriate or incorrect. Go on.
6. Diagrams on examinations are often labelled with numbers or letters. It may be useful to write in the names of the labelled structures or features that you can identify.
7. When reading graphs, use a clear plastic ruler to more accurately extrapolate or interpolate data.
8. Have a good reason for changing an answer. Do not change an answer on a hunch. Do not waste your time looking for patterns of As, Bs, Cs, or Ds in multiple-choice answers. There are none.
9. You may not have time to write and edit a complete rough copy for each written-response question, but you should prepare an outline of your answer and use it as a guide when writing your good copy.
10. When completing a written-response question, keep in mind the reader of your response. The reader will want to know how well you:
 - understand the problem or the mathematical/science concept
 - can correctly use the mathematics involved
 - can use problem-solving strategies and explain your answer and procedures
 - can communicate your solutions and mathematical/science ideas
11. Rewriting a statement of the question is often a good way to begin a written response. Conclude with a summary statement. Be sure you have clearly explained all assumptions and have verified your conclusions.
12. Keep track of the time and pace yourself. Put a check mark by items that you are uncertain about and return to them if there is time at the end of the examination.

Appendix G

Science Process Words

- Hypothesis:** A single proposition intended as a possible explanation for an observed phenomenon; e.g., a possible cause for a specific effect.
- Conclusion:** A proposition that summarizes the extent to which a hypothesis and/or a theory has been supported or contradicted by the evidence.
- Experiment:** A set of manipulations and/or specific observations of nature that allow the testing of hypotheses and/or generalizations.
- Variables:** Conditions that can change in an experiment. Variables in experiments are categorized as:
- *manipulated variables* (independent variables)—conditions that were deliberately changed by the experimenter
 - *controlled variables* (fixed or restrained variables)—conditions that could have changed but did not, because of the intervention of the experimenter
 - *responding variables* (dependent variables)—conditions that changed in response to the change in the manipulated variables

For additional clarification of the specialized words used to describe science process skills, see Al Gibbs, Anton E. Lawson, “The Nature of Scientific Thinking as Reflected by the Work of Biologists & by Biology Textbooks,” *The American Biology Teacher*, March 1992, Volume 54, Number 3, page 137.

- Technology:** The development of our understanding of science is directly related to the development of technology. The meaning of technology has many facets, but in general, technology refers to a way of doing something. This includes the development of tools and new techniques for solving problems. It also includes ideas and their organization for achieving practical purposes. In the context of an examination question, technology includes both these facets of meaning. That is, a technological explanation should include not only identification and descriptions of equipment (tools, products) but also explanations of procedures.

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